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**Assessment of Bacteria and Virus
Emissions at a Refuse Derived Fuel Plant
and Other Waste Handling Facilities**

Midwest Research Inst, Kansas City, MO

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Executive Summary

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EPA-600/8-79-010
August 1979

ASSESSMENT OF BACTERIA AND VIRUS EMISSIONS AT A REFUSE DERIVED
FUEL PLANT AND OTHER WASTE HANDLING FACILITIES

Executive Summary

by

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FOREWORD

The Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution, and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the preservation and treatment of public drinking water supplies and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research, a most vital communications link between the researcher and the user community.

In St. Louis, the City of St. Louis, Union Electric Company and EPA first demonstrated the use of solid waste as a supplementary fuel in coal-fired power plant boilers for generating electricity. In addition to the demonstration, research tasks were conducted to evaluate the relative levels of airborne bacteria and viruses at the St. Louis Refuse Processing Plant and other waste handling facilities for purposes of comparison.

This report was prepared as an executive summary of the report entitled "Assessment of Bacteria and Virus Emissions at a Refuse Derived Fuel Plant and Other Waste Handling Facilities," EPA 600/2-78-152, U.S. Environmental Protection Agency, August 1978. This executive summary presents the results and conclusions of these evaluations.

Francis T. Mayo, Director
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ABSTRACT

This report is an executive summary of results of a program to compare relative levels of selected airborne bacteria and viruses within and around various waste handling facilities. Facilities included were an incinerator, a waste transfer station, a wastewater treatment plant, a landfill, and the St. Louis Refuse Processing Plant. The work also tested the bacteria removal efficiency of a mobile fabric filter.

The results showed that uncontrolled bacteria levels, both in-plant and at the property line, are generally higher for the refuse processing plant than for the other facilities tested. The fabric filter significantly reduced the levels of bacteria in the dust emissions from the refuse plants' air density separator.

This report is of interest to consulting engineers, planners, and government officials involved in resource recovery. A complete discussion of the entire research program is contained in the report entitled "Assessment of Bacteria and Virus Emissions at a Refuse Derived Fuel Plant and Other Waste Handling Facilities," EPA-600/2-78-152, U.S. Environmental Protection Agency, August 1978.

This report was submitted in fulfillment of Contract No. 68-02-1871 by Midwest Research Institute under the sponsorship of the U.S. Environmental Protection Agency.

CONTENTS

Foreword	iii
Abstract	iv
Figures.	vi
Tables	vii
Acknowledgment	viii
1. Introduction.	1
2. Conclusions and Recommendations	3
Conclusions	3
Recommendations	4
3. Test Plan	5
Bacteria and Viruses.	5
Trace Metals.	7
Asbestos.	7
4. Results and Discussion.	9
Bacteria and Virus Hi-Vol Test Results.	9
Statistical Analysis of Hi-Vol Sample Results	21
Bacteria and Virus Andersen Imoactor Test Results	23
Statistical Analysis of Andersen Impactor Sample Results.	26
Bacteria and Virus EPA Mobile Filter Test Results	26
Trace Elements.	27
Asbestos.	29
Literature Search	31
References	33

FIGURES

<u>Number</u>		<u>Page</u>
1	In-plant Hi-Vol samples (total bacteria count) . . .	11
2	In-plant Hi-Vol samples (total coliform)	12
3	In-plant Hi-Vol samples (fecal coliform)	13
4	In-plant Hi-Vol samples (fecal Streptococci)	14
5	Ambient Hi-Vol samples (total bacteria count) . . .	15
6	Ambient Hi-Vol samples (total coliform)	16
7	Ambient Hi-Vol samples (fecal coliform)	17
8	Ambient Hi-Vol samples (fecal Streptococci)	18
9	Summary of statistical differences between plants . .	22
10	Andersen data for upwind and downwind locations (bacteria - total plate count)	24
11	Andersen data for in-plant locations (bacteria - total plate count)	25

TABLES

<u>Number</u>		<u>Page</u>
1	Subject Bacteria and Viruses	7
2	Hi-Vol Sampler Locations	10
3	Ranking of Plants Based on Average Bacterial Levels in Descending Order for Hi-Vol Testing Sites	20
4	Mobile Filter Results	27
5	Trace Elements Concentrations for Hi-Vol Ambient Air Samples	28
6	Trace Elements Results for Air Classifier Discharge Samples	30

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This report was written by Messrs. D. E. Fiscus, P. G. Gorman, M. P. Schrag, and Dr. L. J. Shannon.

SECTION 1

INTRODUCTION

Midwest Research Institute (MRI) has been involved in testing and evaluating the St. Louis-Union Electric Refuse Derived Fuel (RDF) Demonstration Project for the Environmental Protection Agency (EPA) since December of 1973. Environmental evaluations were conducted at the refuse processing plant and the power plant where the RDF was burned. Measurements were for particulates, gases, and trace metals. The tests on particulate emissions at the refuse processing plant also included a preliminary analysis for bacteria and viruses (B&V). Since these particulates consist basically of municipal solid waste (MSW), it was suspected that bacteria might be present in the emissions. These preliminary tests confirmed the presence of microorganisms in the emissions. Therefore, it was decided to conduct a more detailed and definitive investigation.

The objective of the test program was to obtain data that would permit a comparison of the bacterial and viral levels at different types of waste handling facilities and provide a means of evaluating the relative significance of refuse processing operations. In addition to the St. Louis refuse processing plant, for comparative purposes, B&V tests were conducted at four other waste handling facilities; a municipal incinerator, a waste transfer station, a sanitary landfill and a wastewater treatment plant. Tests were conducted at the property line of the processing plant and at certain in-plant locations, as well as at other types of waste handling facilities. In addition to the field test program, a literature search was conducted to assist in interpreting the test results.

In addition to B&V tests, trace element concentrations were determined at the St. Louis Refuse Processing Plant for the discharge of the air classifier system and for upwind/downwind ambient property line locations. The air classifier discharge at St. Louis was assayed for asbestos fibers.

Test results of the B&V trace element and asbestos investigations are presented in summary form in this report. A complete and detailed presentation of all the St. Louis investigations are contained in the following three reports.

1. St. Louis Demonstration Final Report: Refuse Processing Plant Equipment, Facilities, and Environmental Evaluations, Report EPA 600/2-77-155a, U.S. Environmental Protection Agency, September 1977.

2. St. Louis Demonstration Final Report: Power Plant Equipment, Facilities and Environmental Evaluations, Report EPA 600/2-77-155b, U.S. Environmental Protection Agency, December 1977.

3. Assessment of Bacteria and Virus Emissions at a Refuse Derived Fuel Plant and Other Waste Handling Facilities, Report EPA 600/2-78-152, U.S. Environmental Protection Agency, August 1978.

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

The primary purpose of the B&V test program was investigative; i.e., to obtain basic data on levels of B&V in and around waste handling facilities and to perform sampling and analysis for selected trace elements. From the experience gained in acquisition of data and interpretation of results, certain conclusions and recommendations can be presented.*

CONCLUSIONS

- . Airborne bacterial levels, both in-plant and at the property line, were generally higher for the RDF plant than for the other types of waste facilities that were tested.
- . A literature search disclosed that there is insufficient information, data, or relevant standards to determine the levels of microbiological contaminants that might be considered "hazardous."
- . Asbestos emissions from the RDF plant were below the threshold limit value (TLV).
- . Property line concentrations for most airborne particulate containing trace metals were below 1/100 of the TLV.
- . Property line concentrations for Pb contained in the particulate collected were near or exceeded 1/100 of the TLV at the RDF plant, incinerator, and waste transfer station.
- . A fabric filter system applied to the primary source of dust emissions (air classifier) at the refuse processing plant can significantly reduce particulate and bacteria concentrations. The filter (baghouse) tested had better than 99% removal efficiency for both particulates and bacteria.

* These conclusions are based on a test program consisting basically of only three test days at each plant, taking seven 6-hr Hi-Vol filter samples and five short-term Andersen samples each day.

RECOMMENDATIONS

- Waste handling facilities which may emit airborne particulates should be designed and equipped to minimize emissions. Suitable control systems could include process modifications, operating procedures, and dust collection and control equipment.
- There is a need for development of standardized sampling and analysis methodology for airborne microorganisms and other pollutants (e.g., trace metal vapors).
- Further research should be conducted to investigate possible environmental effects of airborne microorganisms associated with waste handling facilities.
- Additional research programs should be conducted at waste handling facilities over longer time periods (e.g., months, years) to better characterize emissions and evaluate any possible environmental or health effects.

SECTION 3

TEST PLAN

BACTERIA AND VIRUSES

The sampling and analysis plan (test plan) was developed through the joint efforts of EPA and MRI. The test plan was also submitted for review to 10 selected experts in the field. The facilities selected for testing were:

- A municipal refuse incinerator
- The St. Louis Refuse Processing Plant
- A sewage treatment plant
- A refuse transfer station
- A sanitary landfill

In addition to the above plants, testing was carried out in downtown St. Louis. Bacterial levels were also ascertained for a refuse collection packer truck. Tests at the refuse processing plant included sampling to determine B&V removal efficiency of a mobile fabric filter (baghouse). This baghouse was tested using a slipstream from the air density separator (ADS) cyclone exhaust duct.

Actual field testing took place in November and early December 1976, with 3 days of testing at each of the above five waste handling facilities.

Two types of sampling equipment were used during the three test days at each plant. Hi-Vol ambient air samplers were used which provide high sampling rates of approximately 19 liters/sec (40 cfm). These air samplers were supplemented by Andersen agar plate impactors with backup impingers to obtain information on the size distribution of the bacteria-containing particles and to determine if any viruses penetrated the impactor into the impinger.

The locations of the equipment at the test sites were as follows: (a) Hi-Vol samplers, one upwind and three downwind, (b) Hi-Vol with precyclone samplers, three in-plant; and (c) Andersen impactors, one upwind, one

downwind, and three in-plant. All upwind and downwind locations were at the property lines.

The placements of the downwind Hi-Vol samplers were: a primary location directly in line with the wind direction from the plant and two secondary locations, one on each side of the primary location to include approximately a 30-degree angle from the upwind location. This placement allowed for normal, slight variations in wind direction. The wind direction was constantly monitored by a strip chart recorder which was checked hourly by the test crew. When a major change in wind direction occurred, the Hi-Vols were moved to be in line with the wind. The Andersen impactor samples were taken at the same locations as the upwind and primary downwind Hi-Vols.

The locations of the in-plant Hi-Vols were selected for each test site to sample the areas where the B&V counts were suspected to be at the highest levels. The Andersen impactors were operated at the same in-plant locations as the Hi-Vols. One Andersen sample was taken at each of the three in-plant locations on each test day.

The sample period for the Hi-Vols was approximately 6 hr at all locations. The sample period for the Andersen impactors was 10 min for the upwind and downwind locations and 30 sec for the in-plant locations. The sampling times for the in-plant and property line Andersen impactors were different because of the suspected higher concentrations of in-plant bacteria and because it is undesirable to overload the agar plates in the Andersen sampler.

During the sampling periods for the incinerator and the processing plant, additional Hi-Vol samples were taken at 12th and Clark Streets in downtown St. Louis, Missouri. This location is a busy intersection with normal downtown city pedestrian and vehicle traffic. These samples were taken as representative of an urban location. Also, two Hi-Vol samplers were attached to the back of a 15 m³ (20 cubic yards) packer truck and were operated on 3 days when the crew was picking up MSW on three different collection routes.

Tests to define the performance of the mobile fabric filter on the ADS exhaust stream were also conducted during the sampling activity at the processing plant. These tests involved:

- A Hi-Vol sampler in the ADS exhaust duct.
- Impinger samplers at the inlet and outlet of a mobile filter on a sidestream taken from the ADS exhaust duct.
- Refuse grab samples taken on the product discharged from the refuse shredder.

Selection of the B&V analyses that were to be performed on the property line and in-plant Hi-Vol samples was an important part of the test plan development. Ultimately, it was decided that each sample would be analyzed for the B&V types shown in Table 1.

TABLE 1. SUBJECT BACTERIA AND VIRUSES

Bacteria	Viruses
Total aerobic plate count	Estimations of population sizes of adenoviruses and enteroviruses. To be done using one cell line to determine number of plaque-forming units (PFU) present.
Salmonellae - Most Probable Number (MPN)	
<u>Staphylococcus aureus</u> (direct plate count)	
Total coliform (MPN)	
Fecal coliform (MPN)	
Fecal Streptococci (direct plate count)	
<u>Klebsiella</u> sp. (estimated from selective media)	

B&V assays of the property line and in-plant Hi-Vol filters, plus the total bacteria colony counts from the Andersen impactors, were the focal point of this program. The primary purpose in obtaining these data was to compare the data for the processing plant with those of the other four facilities. The Hi-Vol filter sampling methodology was utilized because it provides long-term high flow rate sampling capability. However, B&V concentrations must not be considered as absolute values because this type of sampling method probably produces considerable die-off of bacteria. The data best serve only the intended purpose, a comparison of facilities.

TRACE METALS

A portion of the sampling program involved use of part of the Hi-Vol filters for trace element analysis. Those filters samples which were analyzed were from the upwind and downwind locations at each of the five plants plus two downtown samples and the three air classifier discharge samples.

ASBESTOS

It was originally intended that samples taken at the air classifier would be analyzed for asbestos content as would the upwind, downwind, and

downtown Hi-Vol samples. Unfortunately, the glass fiber filter papers used in the Hi-Vol for all analyses (bacteria and trace metals) were not suitable for asbestos analysis since asbestos analysis requires the use of 0.8 μm pore size Nuclepore filter. Asbestos analysis could only be carried out on the air classifier exhaust where a large amount of sample was collected.

SECTION 4

RESULTS AND DISCUSSION

It was intended that comparisons be made for both bacteria and viruses. However, all virus assays were negative so no comparisons are possible. A comparison of bacteria levels at each of the plants was carried out using both the Hi-Vol sample results and the Andersen impactor results for four of the seven species tested. No results are presented for Salmonella sp., Staphylococcus aureus, and Klebsiella sp. because all results were negative for Salmonella, and Staphylococcus and Klebsiella were detected in only four samples. It is inferred that the number or viability (or both) for the latter two species is low.

Results of the analysis of the Hi-Vol filters for the remaining four bacteria types and the Andersen agar plate impactors are discussed next, followed by a discussion of the results for the trace element tests, the asbestos tests, and the literature search.

BACTERIA AND VIRUS HI-VOL TEST RESULTS

Hi-Vol samplers were located at the property line and in-plant at the locations listed in Table 2. Results for all of the Hi-Vol samples are presented in graphical form in Figures 1 through 8. Figures 1 through 4 show the in-plant Hi-Vol results while Figures 5 through 8 show the ambient (property line) results. Each bar in these graphs shows the range of the data (highest and lowest); the average is indicated in the bar. Each bar (and each average value) represents only three data points (i.e., three test days). However, for the downwind results shown in Figures 5 through 8, each bar (and each average value) represents nine data points (i.e., three downwind samples on each of the three test days).

Testing was carried out at the incinerator and the processing plant, which are side by side. The processing plant was not in operation during the tests at the incinerator, but the incinerator was required to be in operation during the tests at the processing plant. The proximity of these two facilities is such that one cannot be sure that the downwind samplers at the processing plant were not affected by the incinerator. However, the upwind sampler was always at a location where it would not be affected by the incinerator.

TABLE 2. HI-VOL SAMPLER LOCATIONS

Processing plant	Incinerator	Waste transfer station	Wastewater treatment plant	Sanitary landfill
Upwind	Upwind	Upwind	Upwind	Upwind
Downwind (3)	Downwind (3)	Downwind (3)	Downwind (3)	Downwind (3)
Control room	Scale room	Truck ramp	Primary settling basin	Scale
Packer station	Crane	Tipping floor	Aeration basin	Working face
Tipping floor	Tipping floor	Tipping floor	Pressroom	Working face
	Packer truck (2)		Pressroom basement	
Downtown	Downtown			

Note: One sampler was used at each location unless otherwise specified by number in parentheses.

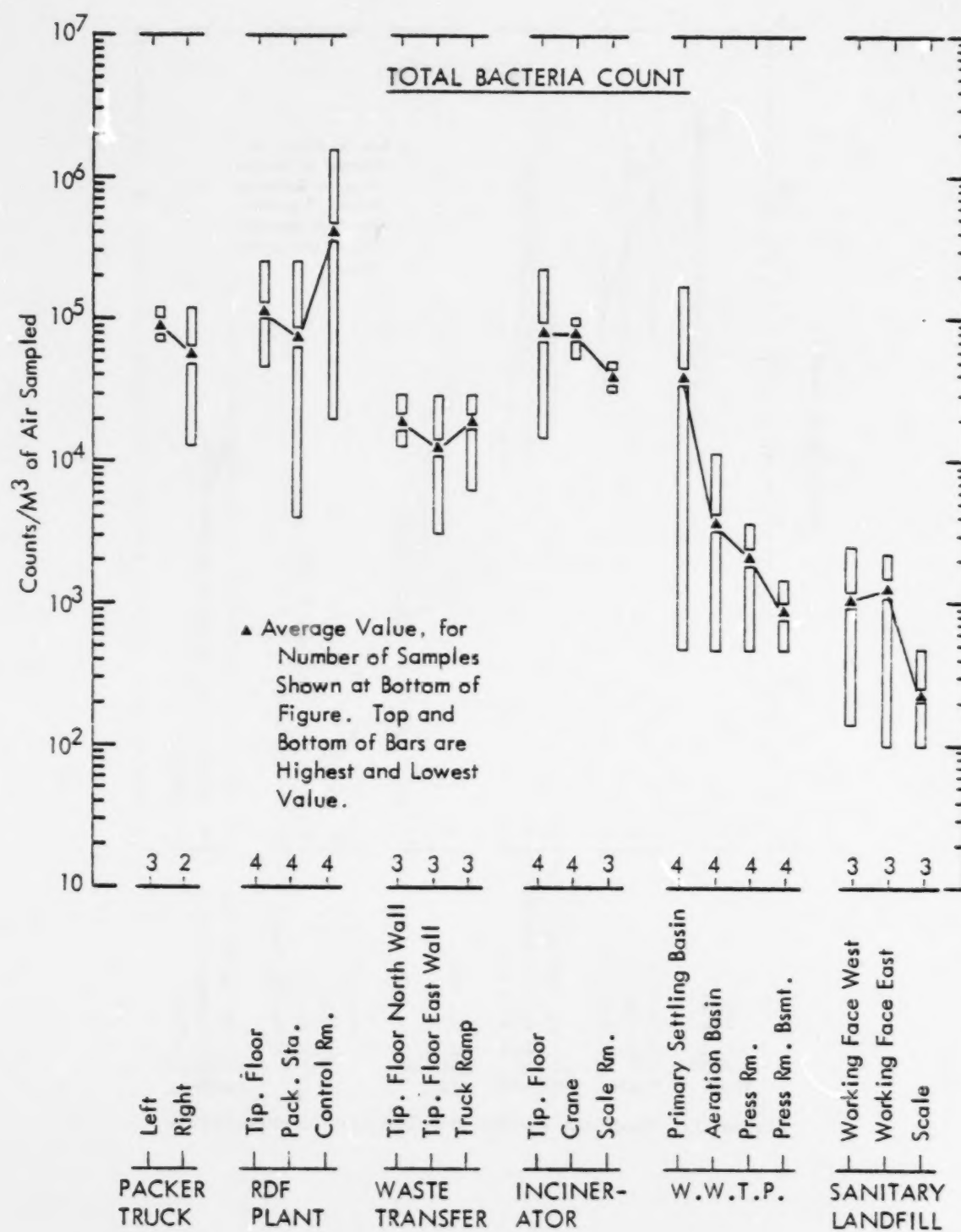


Figure 1. In-plant Hi-Vol sampled (total bacteria count).

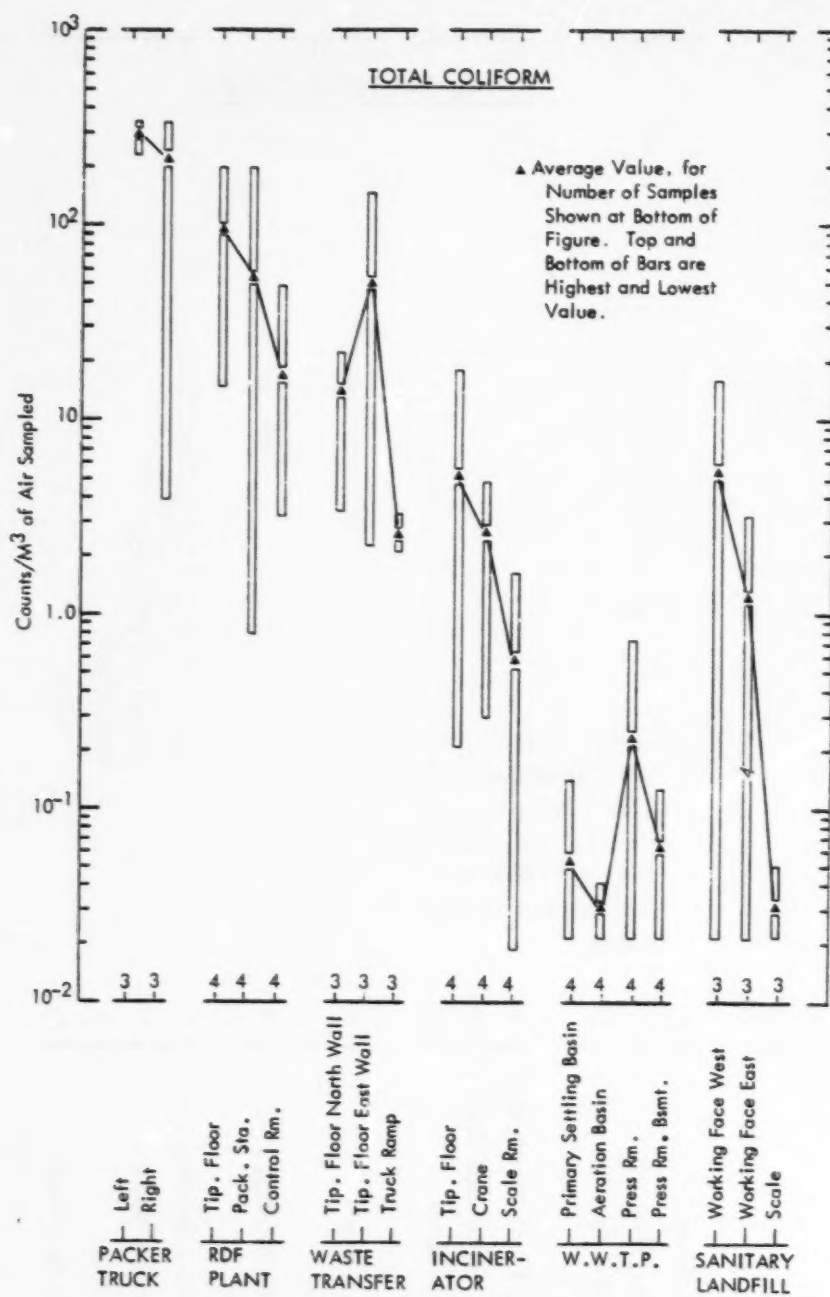


Figure 2. In-plant Hi-Vol samples (total coliform).

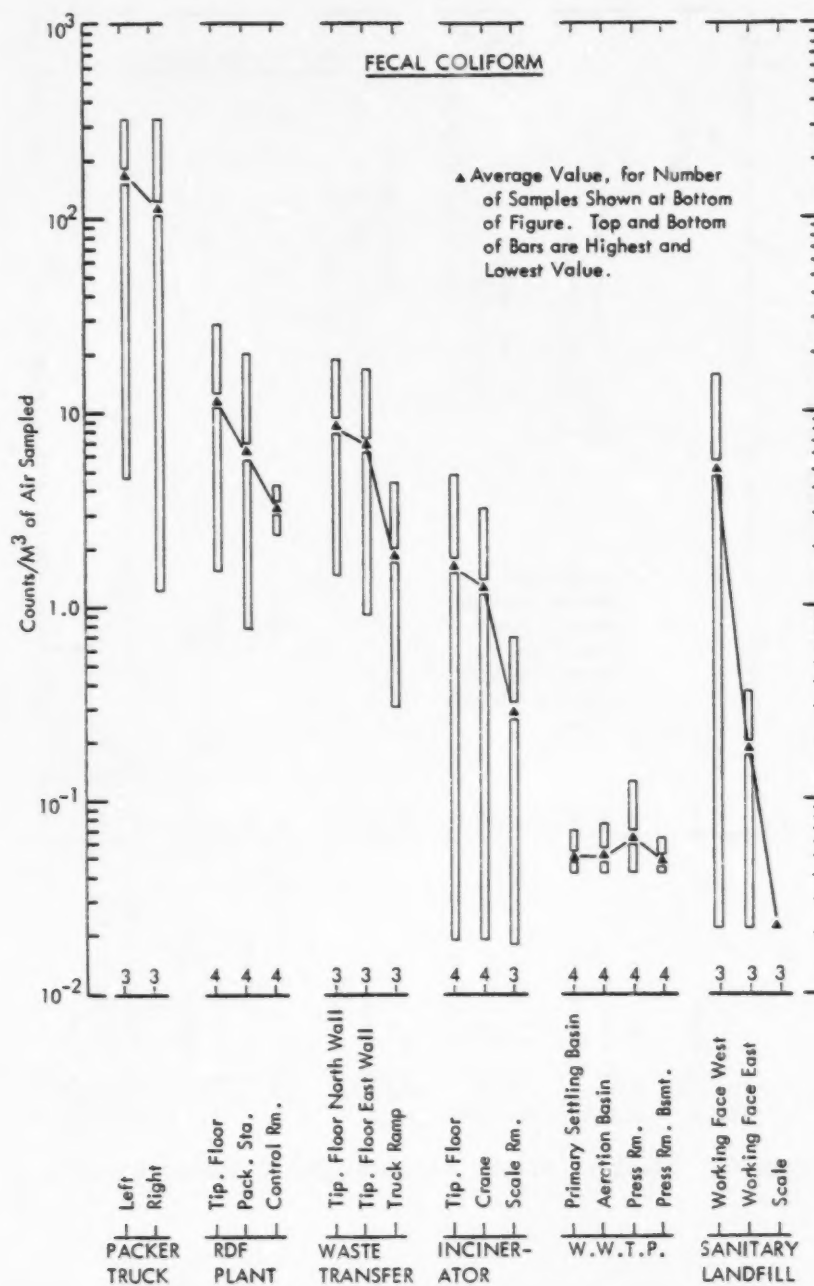


Figure 3. In-plant Hi-Vol samples (fecal coliform).

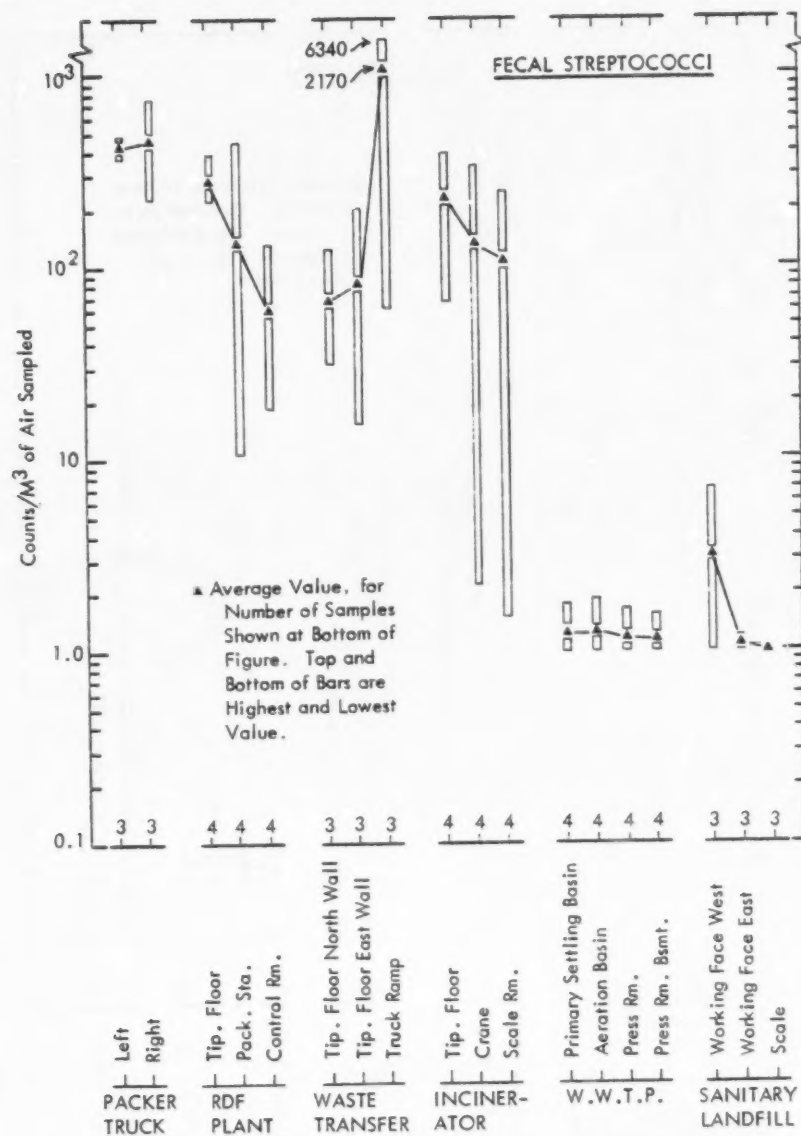


Figure 4. In-plant Hi-Vol samples (fecal Streptococci).

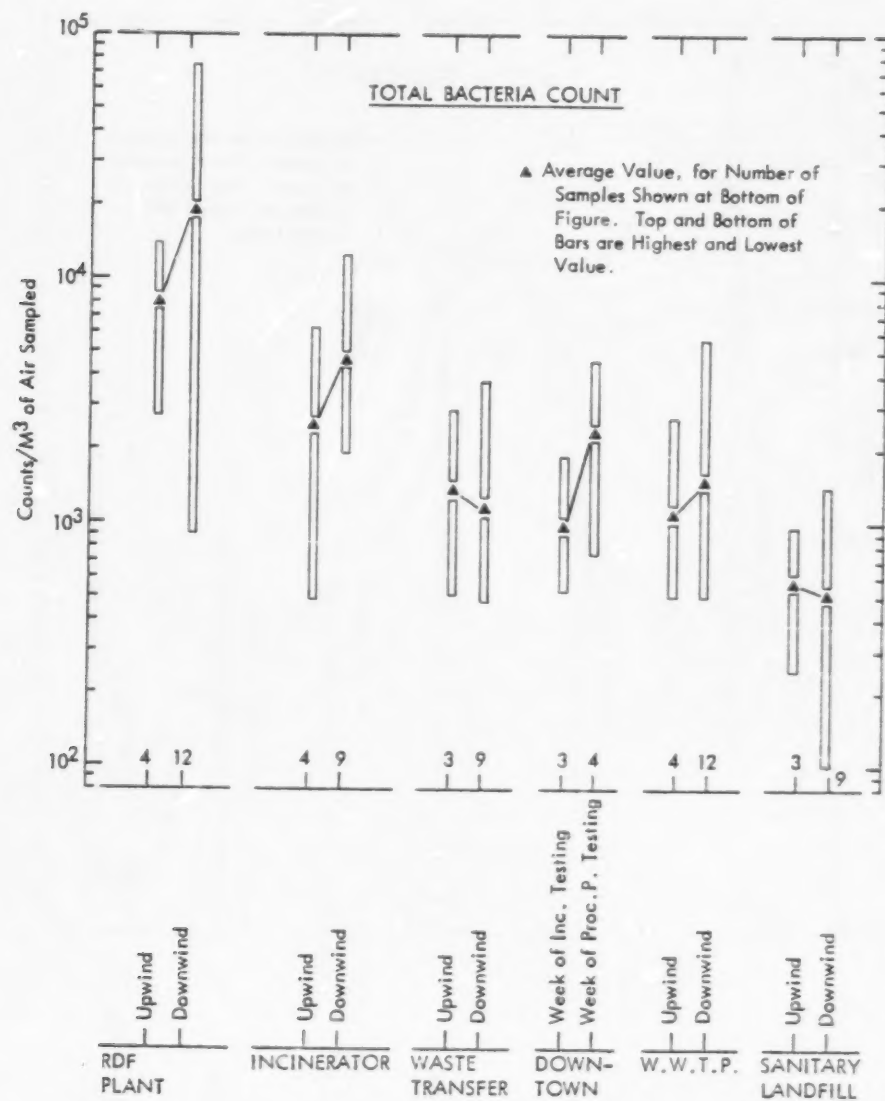


Figure 5. Ambient Hi-Vol samples (total bacteria count).

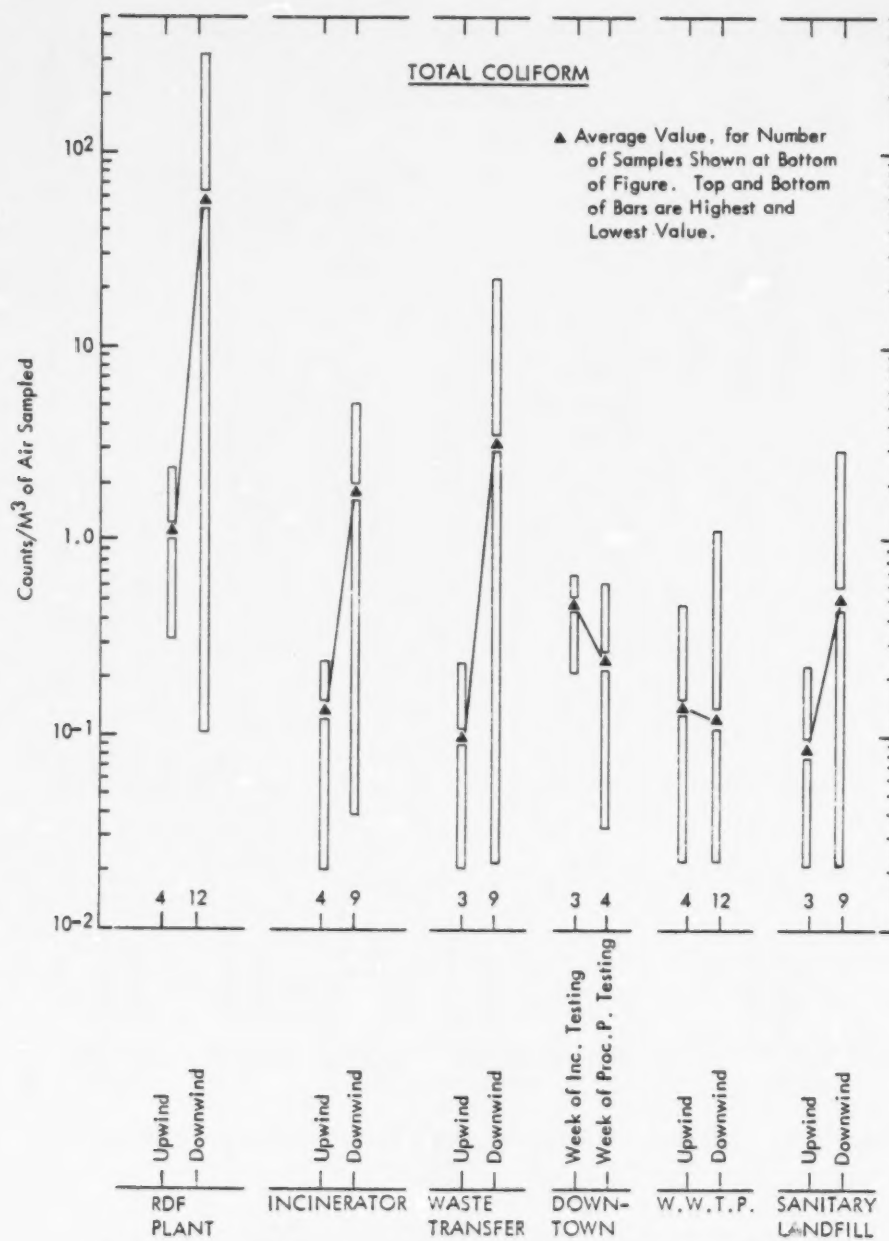


Figure 6. Ambient Hi-Vol samples (total coliform).

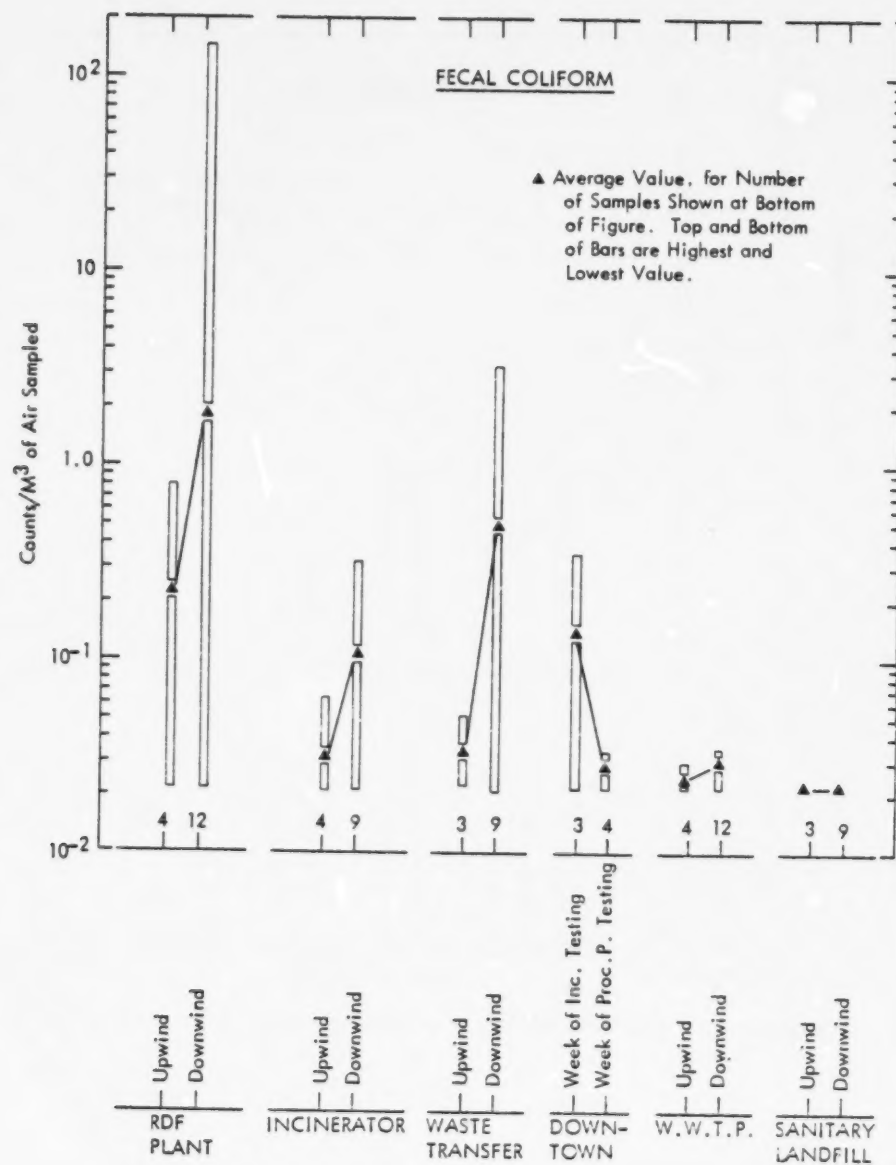


Figure 7. Ambient Hi-Vol samples (fecal coliform).

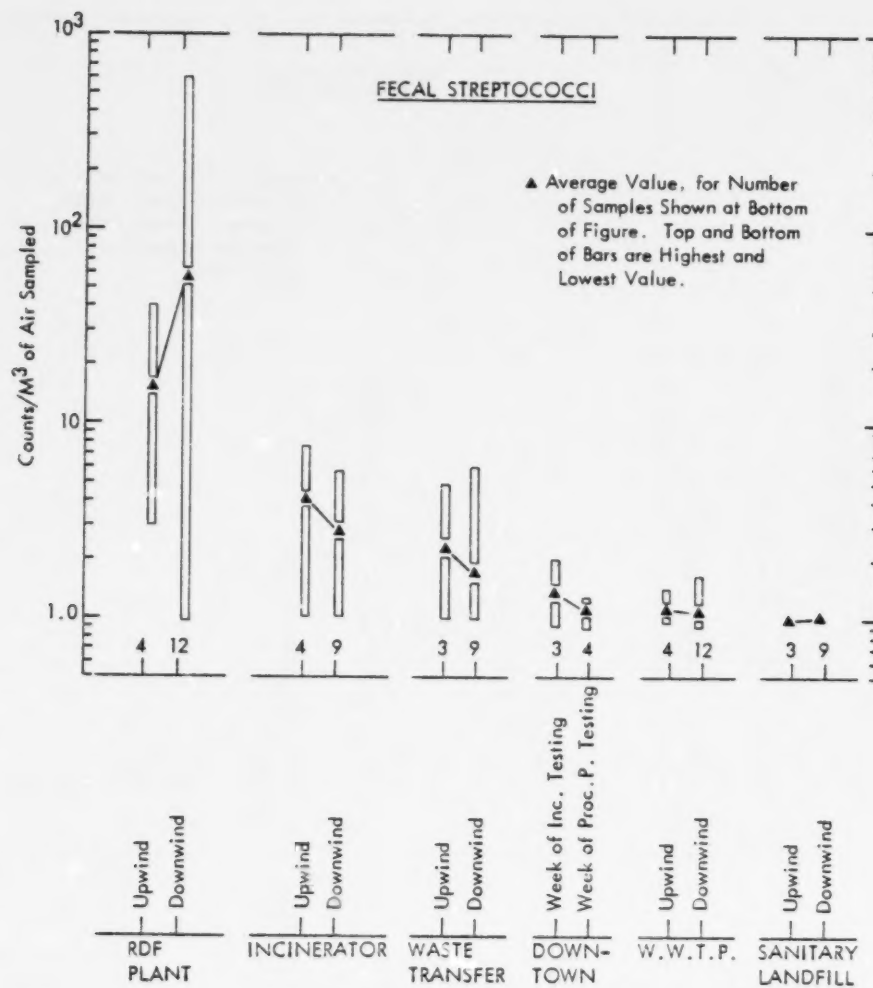


Figure 8. Ambient Hi-Vol samples (fecal Streptococci).

The layout of the two facilities and the existing wind direction during the tests make it unlikely that the in-plant samplers at the processing plant would be significantly affected by the incinerator.

Evaluation of the data in Figures 1 through 8 is done only for purposes of comparison. Individual values should not be considered as absolute, primarily because the long-term Hi-Vol sampling method may have resulted in some die-off for many types of bacteria that might have been collected on the filter during the 6 hr of sampling.

Initial examination of the Hi-Vol data on total bacteria counts (Figures 1 and 5) shows the same general trend from plant to plant, with the processing plant having the highest average count and the landfill having the lowest. The packer truck also had a rather high average value. For the ambient samples, the processing plant had the highest average value. However, the processing plant also had the highest average upwind value, which makes it more difficult to conclude that it has a greater effect on downwind bacterial levels than do the other facilities.

Further examination of the other figures showing ambient Hi-Vol results (Figures 6 through 8) indicates that the processing plant had the highest downwind levels of total coliform, fecal coliform, and fecal Streptococci. The sewage treatment plant and the landfill generally had the lowest levels for all four bacteria groups.

The upwind and downwind levels of microorganisms were about the same for the sewage treatment plant and the landfill (except for total coliform). Conversely, the average downwind values for the processing plant were always higher than upwind values for all four bacteria groups. The average downwind value for the incinerator was higher than the upwind value for three of the four groups. Finally, the waste transfer station indicated an average downwind value that was higher for two of the groups. A rank ordering of the plants based on the ambient Hi-Vol bacteria results is shown in Table 3 along with a ranking based on the in-plant Hi-Vol results.

The in-plant Hi-Vol results (Figures 1 through 4) show roughly the same relative relationship from plant to plant as the ambient Hi-Vol results. However, the in-plant sites include the packer truck, which showed bacterial levels comparable with the highest of other locations that were actually located within a plant. Although workers in the processing plant may be exposed to bacterial levels somewhat higher than at the incinerator (e.g., fecal coliform), the levels are about the same as, or lower than, those to which the packer truck operators may be exposed.

TABLE 3. RANKING OF PLANTS BASED ON AVERAGE BACTERIAL LEVELS IN DESCENDING ORDER FOR HI-VOL TESTING SITES

	Total bacteria		Fecal	
	count	coliform	coliform	Streptococci
In-plant samples				
RDF plant	Packer truck	Packer truck	Packer truck	Waste transfer
Packer truck	RDF plant	RDF plant	RDF plant	Packer truck
Incinerator	Waste transfer	Waste transfer	Waste transfer	RDF plant
Waste transfer	Incinerator	Incinerator	Incinerator	Incinerator
WWTP	Landfill	Landfill	Landfill	Landfill
Landfill	WWTP	WWTP	WWTP	WWTP
Ambient samples				
Upwind (and downtown)				
RDF plant	RDF plant	RDF plant	RDF plant	RDF plant
Incinerator	Downtown	Downtown	Downtown	Incinerator
Downtown	Incinerator	Incinerator	Waste transfer	Waste transfer
Waste transfer	WWTP	WWTP	Incinerator	Downtown
WWTP	Waste transfer	Waste transfer	WWTP	WWTP
Landfill	Landfill	Landfill	Landfill	Landfill
Downwind (and downtown)				
RDF plant	RDF plant	RDF plant	RDF plant	RDF plant
Incinerator	Waste transfer	Waste transfer	Waste transfer	Incinerator
Downtown	Incinerator	Incinerator	Incinerator	Waste transfer
WWTP	Landfill	Landfill	WWTP	Downtown
Waste transfer	Downtown	Downtown	Downtown	WWTP
Landfill	WWTP	WWTP	Landfill	Landfill

STATISTICAL ANALYSIS OF HI-VOL SAMPLE RESULTS

Although the Hi-Vol data shown in Figures 1 through 8 do show some obvious differences between plants, it is also obvious that results at any one location sometimes varied by several orders of magnitude. A statistical treatment was applied to these data to determine if significant differences did exist between the various plants.

Because tests at each sampling location were replicated either three or four times, the mean ($\bar{X}$) and the standard deviation (S_x) of the test replications were calculated. The means were then compared to the standard deviations using a curve fit computer program. It was found that the mean was proportional to the standard deviation [$S_x = F(\bar{X})$] with greater than 90% correlation. Therefore, the distribution was not normal as would be the case if $S_x = \text{a constant}$.

Since $S_x = F(\bar{X})$, the distribution is empirical. To stabilize its variances, the log normal transformation of the test results, as recommended by Johnson (4), was performed. Next, an analysis of variance was conducted on the transformed data using a computer program capable of accepting data from unbalanced experimental designs.

For those categories that were statistically significant, as shown by the analysis of variance, it was then necessary to perform posteriori tests to ascertain significant differences between plants. The Newman-Keuls method (modified Q test) as presented by Snedecor (5) was used because this method gives good protection against erroneous claims of significance.

The analysis of variance performed on the Hi-Vol data showed that at the 95% confidence level significant differences existed. Figure 9 presents the results of the Q test, showing at the 95% confidence level which plants are significantly different from each other.

The comparisons between plants show that:

- Upwind counts per cubic meter of bacteria in air generally were not affected by the individual plant. However, for total coliform and fecal Streptococci, the processing upwind samples had statistically significantly higher counts than any of the other plants. For total bacteria count, the processing plant was higher than all other plants except the incinerator. The other four plants were not significantly different from each other for any bacteria species. What effect the higher upwind concentrations at the processing plant had on the downwind and in-plant samples is unknown.

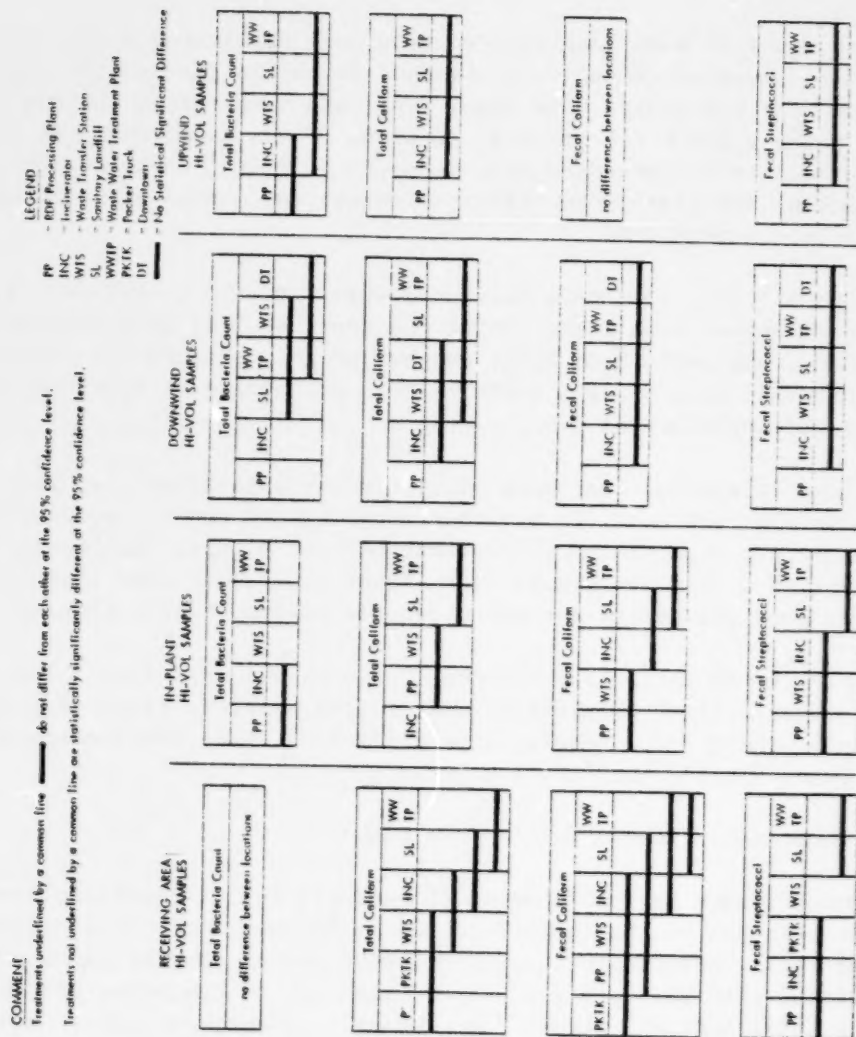


Figure 9. Summary of statistical differences between plants.

- For downwind samples, the processing plant had significantly higher concentrations than all other locales for all bacteria species. For total bacteria count, and to a lesser extent for total coliform, there were several significant differences between the other locales. However, for fecal coliform and fecal Streptococci, there were no statistically significant differences between the other locales, including the downtown location.
- Analysis of the in-plant samples showed several differences between plants for the four bacteria species. The processing plant was always significantly higher than the sanitary landfill and the wastewater treatment plant for all bacteria species, and it was higher than the waste transfer station for total bacteria count. However, there was no significant difference between the processing plant and the incinerator for total bacteria count and between the processing plant and the waste transfer station for total coliform and fecal coliform. For fecal Streptococci, there were no statistically significant differences between the processing plant and both the incinerator and the waste transfer station.
- Comparison of the various receiving area locales, including the packer truck, showed that there were no significant differences between locales for total bacteria count. For total coliform concentrations at the receiving areas, there were no significant differences between the RDF plant, the packer truck, and the waste transfer station. There were several other differences between plants. For fecal coliform in the receiving areas, the RDF plant was no different from any other plant or the packer truck except the wastewater treatment plant, which had lower concentrations. However, for fecal Streptococcus, which is a known pathogen, the RDF plant receiving area concentrations were not significantly different from either the incinerator receiving area or the packer truck. The sanitary landfill and the wastewater treatment plant had the lowest values.

BACTERIA AND VIRUS ANDERSEN IMPACTOR TEST RESULTS

Andersen agar plate impactor samples were taken during each test day at each plant at the same locations as the Hi-Vol samplers in order to obtain size distributions of bacteria or bacteria-containing dust particles (total bacteria count on each stage). A summation of the counts at each stage was made to calculate a total bacteria count per cubic meter of air at each test location; these results are shown in Figures 10 and 11. Both of these figures show the same general trend from plant to plant as the Hi-Vol samples discussed earlier. The Andersen data also confirm the previous finding from the Hi-Vols, that the processing plant had the highest

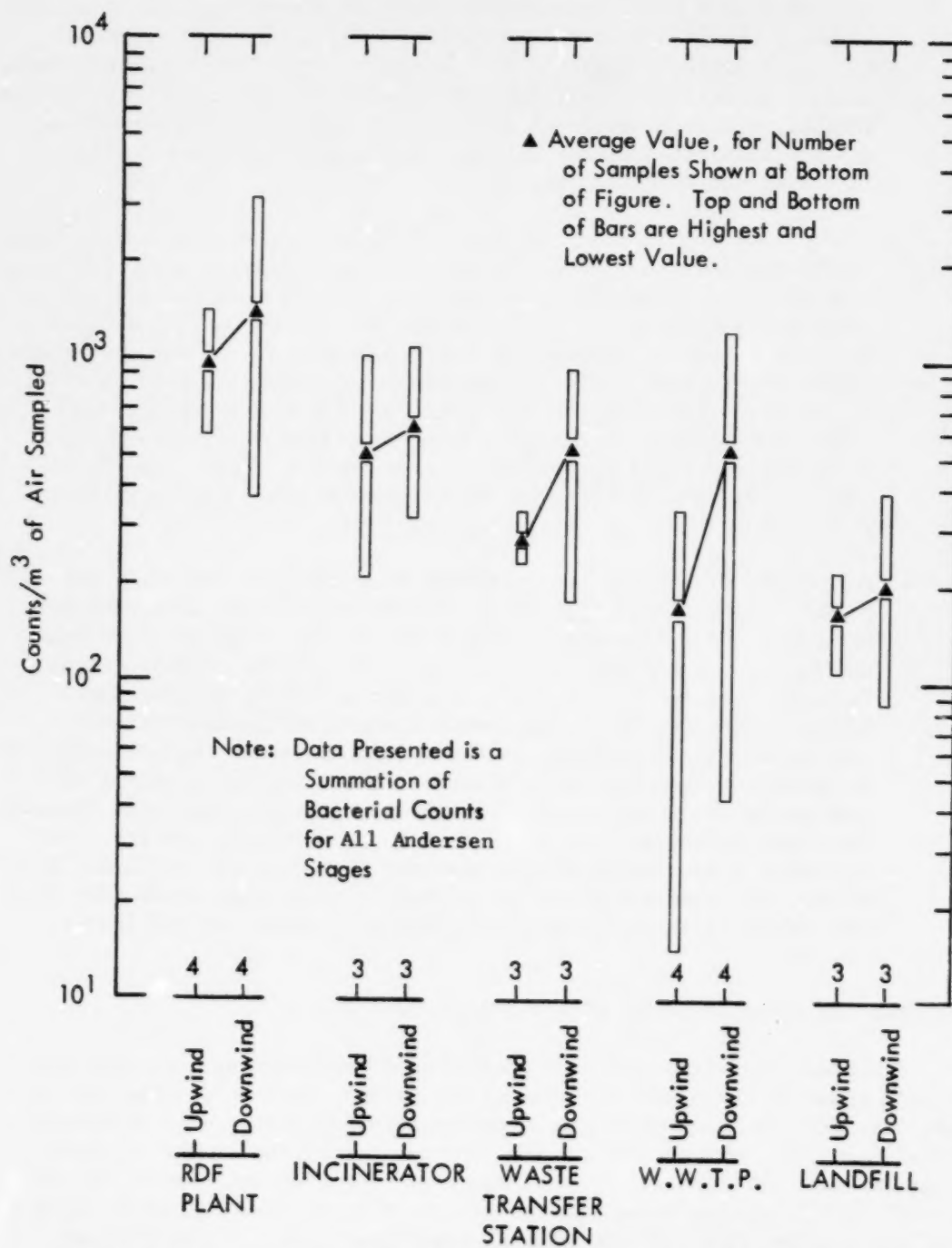


Figure 10. Andersen data for upwind and downwind locations (bacteria - total plate counts).

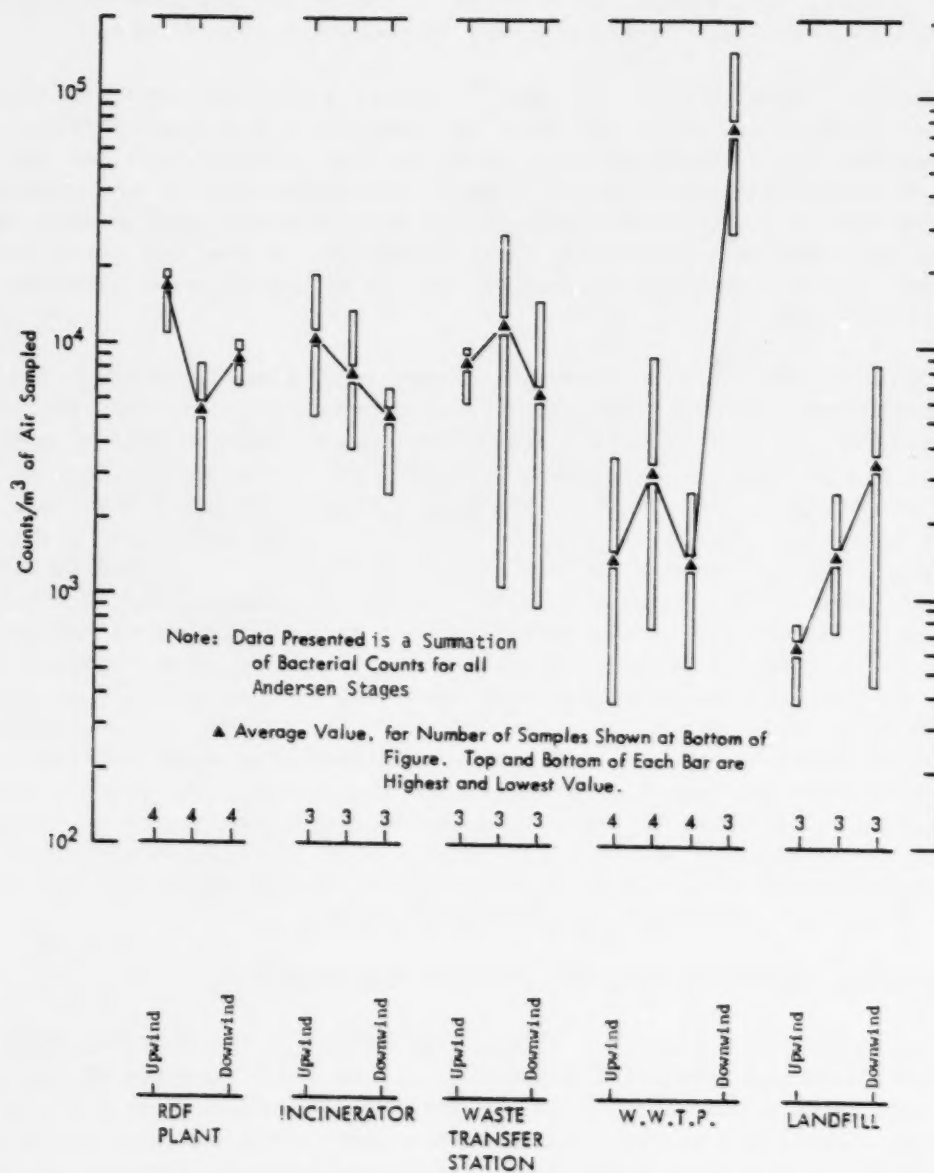


Figure 11. Andersen data for in-plant locations (bacteria - total plate counts).

upwind values. The average upwind value at the processing plant was greater than the average downwind value at any of the other four plants.

In-plant Andersen data (Figure 11) indicate that the number of bacteria-containing particles was about the same for the processing plant, incinerator, and waste transfer station, but was somewhat less for the sewage treatment plant and landfill. The pressroom basement at the treatment plant is one very obvious departure from this. Andersen samples were taken in the pressroom basement during the time the filter cake was being dumped, and this activity produced the highest values of any in-plant location for the Andersen samples.

The distribution of the counts on each stage showed, unexpectedly, a rather erratic distribution rather than decreasing counts with decreasing size. If one were measuring size distribution based on mass of particles, there would normally be less mass of smaller particles present than of larger ones. At the same time, however, the number of smaller particles could still be the same as, or greater than, the number of larger particles. Also, it is theorized that bacteria are not free-floating but are carried in air by "host" particulate matter. In view of this, the results should not be unexpected because the agar impactor test is more indicative of the number of particles containing bacteria within each size range than the mass of particles itself. Consequently, these data tend to show that the air sampled at most locations did not contain decreasing numbers of bacteria with decreasing size. However, little can be said about the number of bacteria associated with each particle size because the Andersen impactor data do not indicate the number of bacteria associated with each particle. That is, one large particle and one small particle could well contain grossly different numbers of bacteria, but each would still produce only one colony count on the two respective agar impactor stages.

STATISTICAL ANALYSIS OF ANDERSEN IMPACTOR SAMPLE RESULTS

A statistical analysis of variance performed on the Andersen impactor data confirmed that the total bacteria count is not a function of particle size. The F-ratio calculated from the analysis of variance was 1.27 for impactor stages, and at the 95% confidence level there was no significant difference in counts per stage for the Andersen impactor samples. Therefore, total bacteria concentrations in air are randomly dispersed throughout the particle size range represented by the Andersen stages (1 μm to greater than 7 μm).

BACTERIA AND VIRUS EPA MOBILE FILTER TEST RESULTS

The EPA mobile filter was used during the 3 days of testing at the processing plant in conjunction with the other B&V tests. This mobile

filter was connected to a sidestream drawoff from the ADS cyclone exhaust at a flow rate of 0.05 dNm³/sec.

The filter test results showed an inlet particulate concentration of 0.300 g/Nm³ and an outlet concentration of 0.000154 g/Nm³, yielding a total mass efficiency of 99.95%. This efficiency is about what would be expected for a baghouse in this service, indicating that such devices are very effective in reducing particulate emissions.

During the particulate tests on the EPA mobile filter, impinger samples were taken at the inlet and outlet of the filter. Results of those tests, as given in Table 4, show a significant decrease in bacterial levels across the mobile filter, indicating a removal efficiency of 99.6% for total bacteria and at least 99.9% for total coliform, fecal coliform, and fecal Streptococci.

TABLE 4. MOBILE FILTER RESULTS

Sample	Total bacteria count	Total coliform	Fecal coliform	Fecal Streptococci
Filter inlet (counts/m ³)	5.25 x 10 ⁸	3.36 x 10 ⁶	4.62 x 10 ⁵	2.25 x 10 ⁶
Filter outlet (counts/m ³)	2.1 x 10 ⁶	3.57 x 10 ²	2.3 x 10 ²	2.1 x 10 ³
Filter removal efficiency	99.6%	99.99%	99.95%	99.91%

TRACE ELEMENTS

Portions of the Hi-Vol filter used in the bacteria tests were also submitted for trace metal analysis. Elemental concentrations at the property lines of the plants (upwind and downwind) and downtown, as given in Table 5 allow four main observations:

- For most elements there was a significant increase in the downwind concentration at the RDF plant and the waste transfer station.

TABLE 5. TRACE ELEMENT CONCENTRATIONS FOR HI-VOL AMBIENT AIR SAMPLES

Location	Date	Element Concentrations ($\mu\text{g}/\text{m}^3$)									
		Sb	As	Be	Cd	Cr	Cu	Pb	Hg	Se	Zn
<u>Incinerator</u>											
Upwind	11/3/76	b/	b/	0.00036	0.0025	< 0.05	0.12	0.93	b/	b/	0.42
Downwind	11/3/76	b/	b/	0.00018	0.003	< 0.05	0.10	2.50	b/	b/	0.32
Downtown	11/3/76	b/	< 0.008	0.00020	0.002	< 0.05	0.05	0.97	b/	b/	0.13
<u>RDF plant</u>											
Upwind	11/10/76	b/	b/	0.00017	0.002	< 0.05	0.44	0.69	b/	b/	0.30
Downwind	11/10/76	b/	0.015	0.00056	0.007	0.17	0.39	2.25	b/	b/	1.96
Downtown	11/10/76	b/	b/	<0.00010	0.0005	< 0.05	0.10	0.83	b/	b/	0.07
<u>WTP^a</u>											
Upwind	11/16/76	b/	b/	0.00006	0.0026	< 0.05	0.13	0.64	b/	b/	0.12
Downwind	11/16/76	b/	b/	0.00013	0.003	< 0.05	0.22	0.98	b/	b/	0.13
<u>Waste Transfer</u>											
Upwind	11/24/76	b/	b/	0.00014	0.002	0.17	0.13	< 0.5	b/	b/	0.24
Downwind	11/24/76	b/	0.009	0.00022	0.002	0.14	0.18	1.5	b/	b/	0.20
<u>Landfill</u>											
Upwind	11/30/76	b/	b/	<0.00007	0.0015	< 0.05	0.07	1.18	b/	b/	0.06
Downwind	11/30/76	b/	b/	0.00020	0.0005	< 0.05	0.05	0.59	b/	b/	0.09
TLW/100		0.50	0.50	0.02	0.50	1.0	2.0	1.5	0.50	2.0	5.0

^a/ Wastewater treatment plant.

b/ All values below detection limits (Sb-0.02, As-0.007, Hg-0.002, Se-0.04).

- There was a significant increase in the downwind Cr concentration at the RDF plant, and both the upwind and downwind Cr concentrations were much higher at the waste transfer station than at all other plants (except the RDF plant).
- There was a significant increase in the downwind Zn concentration at the RDF plant.
- The downwind Pb concentration was higher than the upwind at all plants except the landfill.

Since there are no ambient air standards for most of the trace elements, it is difficult to assess the above results in terms of potential hazards. However, if one assumes that such results can be compared with 1/100 of TLV as an arbitrary level, then initial comparison can be made. On this basis, the data in Table 5 show that all of the measured trace element concentrations were considerably below 1/100 of the respective TLVs, except for Pb.

Concentrations of Pb were close to 1/100 of TLV even in the upwind and downtown samples. But the downwind Pb concentrations exceeded 1/100 of TLV at the incinerator and RDF plant and were just equal to 1/100 of TLV at the waste transfer station. It appears that operation of such refuse handling facilities may contribute significantly to the burden of Pb in the ambient air. This means that more emphasis must be placed on the Pb concentration in emissions from the uncontrolled air classifier system. Although Pb and other trace elements were not measured in the outlet from the mobile fabric filter, the high total particulate efficiency would be expected to also reduce the associated Pb emissions.

Table 6 shows the trace element concentrations in the particulate matter emitted from the air classifier system and the concentration in terms of volume of air discharged.

Examination of the air classifier discharge results in Table 6 shows that Pb and Zn have by far the highest concentration. However, all of the trace elements analyzed, including Pb and Zn, were below their respective TLVs.

ASBESTOS

The results for the air classifier exhaust samples showed that 15 out of 19 fibers were asbestos in one sample. In the other sample, 18% of the fibers were analyzed, and all were determined to be asbestos so it was assumed that all fibers were asbestos. On a weight basis, it was calculated that the mass of asbestos fibers per mass of sample material was 1.6 and 0.46%, respectively.

TABLE 6. TRACE ELEMENT RESULTS FOR AIR CLASSIFIER DISCHARGE SAMPLES

Sample	Trace element concentration ($\mu\text{g/g}$)									
	Sb	As	Be	Cd	Cr	Cu	Pb	Hg	Se	Zn
1	< 5.0	22.0	0.22	19.0	83.0	74.0	430.0	0.93	30.0	680.0
2	4.2	9.1	0.18	7.0	78.0	60.0	370.0	0.35	28.0	520.0
3	7.7	5.7	0.23	4.6	97.0	100.0	400.0	< 0.40	25.0	740.0
	Trace element concentration ($\mu\text{g/m}^3$)									
1	1.3	5.8	0.058	5.0	21.7	19.0	113.0	0.24	7.9	178.0
2	1.5	3.3	0.065	2.5	28.0	21.5	133.0	0.13	10.0	187.0
3	2.1	1.5	0.062	1.2	26.0	27.0	107.0	0.11	6.7	198.0
TIV	50.0	50.0	2.0	50.0	100.0	200.0	150.0	50.0	200.0	5,000.0

Initially it appeared that the amount of asbestos being emitted from the air classifier could be significant. The data showed the highest concentration sample contained 15 fibers in 35.6 μg of particulate sample; but when coupled with the particulate concentration of 0.23 $\mu\text{g}/\text{cc}$ of air, it is calculated that the air classifier was emitting 0.10 fiber of asbestos per cubic centimeter of air. This emission quantity is considerably below the TLV of 5 fibers/ cm^3 (for fibers greater than 5 μm in length) Many of the asbestos fibers identified were less than 5 μm in length so it is uncertain whether comparison with the TLV is entirely valid. Investigations by the National Academy of Sciences indicate that it is not possible to determine whether the fibrogenicity of asbestos dust is mostly confined to fibers longer than 5 μm . With this uncertainty, the comparison of the test data with the TLV results in the conclusion that emission of asbestos from the air classifier system probably does not represent a potential hazard for the system evaluated.

LITERATURE SEARCH

A comprehensive literature review was conducted to survey various waste treatment industries in order to place health problems from bacterial and viral emissions from MSW processing plants in proper perspective. During the course of the review, 154 references, including many foreign references, were thoroughly evaluated.

Man, like other animals, is always infected by many species of microorganisms, some of which under the right circumstances are capable of producing disease. The probability of bacterial infection primarily depends on four factors:

- . There must be a ready source of the infecting agent.
- . The source must release relatively large numbers of organisms, the rate of release being dependent on the nature of the source.
- . To be transmitted, the infective microbe must be capable of surviving in transit to a new host.
- . For a bacterial disease to occur, the host must be susceptible.

A single microbe can infect a susceptible cell. Practically, however, large numbers of microorganisms are usually required to start an infection because of the various protective mechanisms the human body has developed as a defense against the invasion of microorganisms.

Unfortunately, while much is known concerning microorganisms, there are no established or tentative standards on airborne bacteria concentrations.

There presently is not enough epidemiological evidence to establish the relationship between bacteria concentrations in air and the kind and degree of response by man. The product of an atmospheric concentration and the volumetric flow rate of breathing is the rate of delivery into the respiratory system, but whether this is an infective dose cannot be judged.

In summary, the literature search carried out under this program revealed nothing that would provide a basis for judging whether the bacteria concentrations measured in this study or any other airborne bacterial concentration levels are, or are not, hazardous.

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16. ABSTRACT This report is an executive summary of the work carried out by Midwest Research Institute for the Environmental Protection Agency to determine relative levels of bacteria and viruses for comparison purposes at the St. Louis Refuse Processing Plant and at four other types of waste handling facilities (i.e., an incinerator, a waste transfer station, a wastewater treatment plant, and a landfill). This work also included testing to determine bacterial removal efficiency of a fabric filter (baghouse). Tests for trace elements and asbestos were also conducted. The complete tests are fully reported in the final report, "Assessment of Bacteria and Virus Emissions at a Refuse Derived Fuel Plant and the Waste Handling Facilities," EPA 600/2-78-152, U.S. Environmental Protection Agency, August 1978. The results showed that airborne bacterial levels, both in-plant and at the property line, are generally higher for the refuse processing plant than for the other types of waste handling facilities that were tested. A fabric filter system can significantly reduce particulate and bacteria emissions. Trace metal tests results indicated that only emissions of lead may be of concern.		13. TYPE OF REPORT AND PERIOD COVERED Executive Summary
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